Wireless Biodevices and Systems
Department of Electronics and Biomedical Engineering
Radiofrequency Group
Neus Vidal (nvidal@ub.edu)
The Group

GRAF
Grup de Radio-Freqüència

Integrated RF Passives
Design of Integrated RF Circuits & Systems
Biomedical RF Modules
My Research

Antenna design for biomedical applications and electromagnetic propagation-related issues.
Today

Wireless Biodevices and Systems

- no wires
- sending data
- device constructed from biological components
- device constructed for biomedical applications
- several devices
Outline

1. Introduction
2. Market Analysis
3. Fundamentals
4. LAB
Body-centric wireless communications refer to human networking with the use of wearable and implantable wireless devices. It is a subject area combining Wireless Body Area Networks (WBANs), Wireless Sensor Networks (WSNs) and Wireless Personal Area Networks (WPANs).

Biotelemetry

https://www.youtube.com/watch?v=_2-csvrh8UM
1. Introduction

Wireless **biotelemetry** allows minimally invasive monitoring of physiological parameters, improving the patient’s comfort and care and drastically reducing hospital costs. These advantages will be particularly welcome in the future healthcare scenarios based on **P4 medicine**, especially in view of the current demographic shifts towards more elderly populations and the economic impact that this development is bound to have.

P4 medicine (the four “p”s stand for “Predictive, Preventive, Personalized and Participatory”) has evolved rapidly over the last decade and represents a revolutionary new medical paradigm which places the individual patient at the center of healthcare.
On-body or wearable devices are already present in our everyday life. Smart watches and wristbands with sensing capabilities, for instance, are a reality today. New trends in wearable devices will lead to the blossoming of other types of product, such as headwear or eyewear devices for virtual or augmented reality, smart footwear and bodywear for sport and fitness, and so on.

In the healthcare system, wireless on-body devices are being introduced, as they enable noninvasive monitoring of vital signs. However, certain challenges remain unresolved, among them miniaturization, security, standardization, energy efficiency, robustness and unobtrusiveness.
1. Introduction

Most in-body devices are still in development. These devices first appeared in 1958, when Rune Elmgvist et al. succeeded in implanting the first pacemaker in a human body. Since then, in-body devices, commonly known as Implantable Medical Devices, have covered a niche area when physiological parameters are only accessible from inside the human body or when wearable devices were not sufficiently powerful. Nevertheless, apart from implanted pacemakers and some ingestible endoscopic capsules with biotelemetry capabilities, not many in-body medical devices are available on the market; most of them are still in development, at testing or prototyping stage.

In-body wireless devices are classified in implantable, ingestible or injectable depending on their method of insertion into the human body. These devices open up a promising spectrum of new healthcare applications, but the list of challenges to overcome is still longer and more demanding than in the case of wearables: a greater level of miniaturization, biocompatibility, safety considerations, powering, and so on.
Not only monitoring therapies
Example: microwave applicator for the treatment of breast cancer through hyperthermia.
1. Introduction

Scenarios

**Off-body**
The channel is off of the body and in the surrounding space, only one antenna in the communications link is on the body. This is referred to as the off-body domain.

**On-body**
Most of the channel is on the surface of the body and both antennas will be on the body. This is called the on-body domain.

**In-body**
A significant part of the channel is inside the body and implanted transceivers are used. This is called the in-body domain.
1. Introduction

Scenarios

- On $\leftrightarrow$ Out
- On $\leftrightarrow$ On
- In $\leftrightarrow$ On
- In $\leftrightarrow$ Out
- In $\leftrightarrow$ In
2. Market Analysis

According to the **IDTech report** [1], the increasingly diverse market for wearable devices will reach over $150bn annually by 2027. This report contains 10-year forecasts (2017-2027) across 39 categories of wearable technology device, segmented by product type, industry and location on the body.

*Wearable Technology 2017-2027: Markets, Players, Forecasts – IDTech 2017*
2. Market Analysis

Wireless Portable Medical Device Market by *MarketsandMarkets* [2] Analysis by Technology (BT/BLE, Wi-Fi, ZigBee, ANT+), Component (Sensors, ICs, Processors), Application (Monitoring, Medical Therapeutics, Diagnosis, Fitness & Wellness), and Geography, Global Forecast to 2020

**FIGURE 1** WPMD MARKET, BY APPLICATION

- **Monitoring**
  - Cardiac monitor
  - Respiratory monitor
  - Hemodynamic monitor
  - Multiparameter monitor

- **Medical Therapeutics**
  - Programmable syringe pump
  - Infusion pump
  - Anesthesia delivery system

- **Diagnosis**
  - Endoscope
  - Digital thermometer

- **Fitness and Wellness**
  - Wearable electronics
  - Others*
2. Market Analysis

Wearable Market White Papers

Percent starting from 2011.

Global Revenue Forecast for Insulin Pumps

Revenue (US$ millions)

Examples of manufacturers in this market are Animas One Touch, Asante Snap, CeQur PaQ, Insulet Omnipod, Roche Diagnostics Accu-Chek, Smiths

Global Revenue Forecast for Continuous Glucose Monitoring (CGM) Sensors

Revenue (US$ millions)
3. Fundamentals

Basic questions

How can we establish communications?
Using waves and modifying some of their characteristics: amplitude, phase, frequency.

What parameters characterize the propagation of signals?
permittivity (e), conductivity (s), permeability (m)
3. Fundamentals

What kind of radiation do we use to establish wireless communications? Why?

What do we calculate/measure to characterize propagation of signals?
Electromagnetic fields

How can we generate electromagnetic waves for wireless communications?
Using antennas.
An antenna is a device used to transform a RF signal, traveling on a conductor, into an electromagnetic wave.
Antennas have *reciprocity*, an antenna will maintain the same characteristics regardless if it is transmitting or receiving.

3. Fundamentals

![Diagram of wireless communication system]

- **T** (Transmitter)
- **Message**
- **Medium**
- **R** (Receiver)
3. Fundamentals

**What is SAR?**
The specific absorption rate (SAR) is defined as transferred power divided by the mass of the object. Specific refers to the normalization to mass, and absorption rate to the rate of energy absorbed by the object. For sinusoidal steady-state EM fields the time-average SAR is given by:

\[
\text{SAR} = \frac{\sigma_{\text{eff}} E_{\text{rms}}^2}{\rho} \quad (\text{W/kg})
\]

where \( \rho \) is the mass density of the object in kg/m\(^3\), which is close to 1.0 kg/m\(^3\) for most biological tissues (except for lung, which is about 0.347 kg/m\(^3\)).

This is a point relation, so it is often called the local SAR. The space-average SAR for a body or a part of the body is obtained by calculating the local SAR at each point in the body and averaging over the whole body or the part of the body being considered.
3. Fundamentals

Modelling
3. Fundamentals

What is a phantom?
3. Fundamentals
3. Fundamentals
4. LAB

1. Examples: far field, near-field devices, antennas
2. Spectrum analyzer: levels, bands, technologies
3. Anechoic chamber
4. Spectrum analyzer inside the chamber
5. Phantoms
6. Measurements